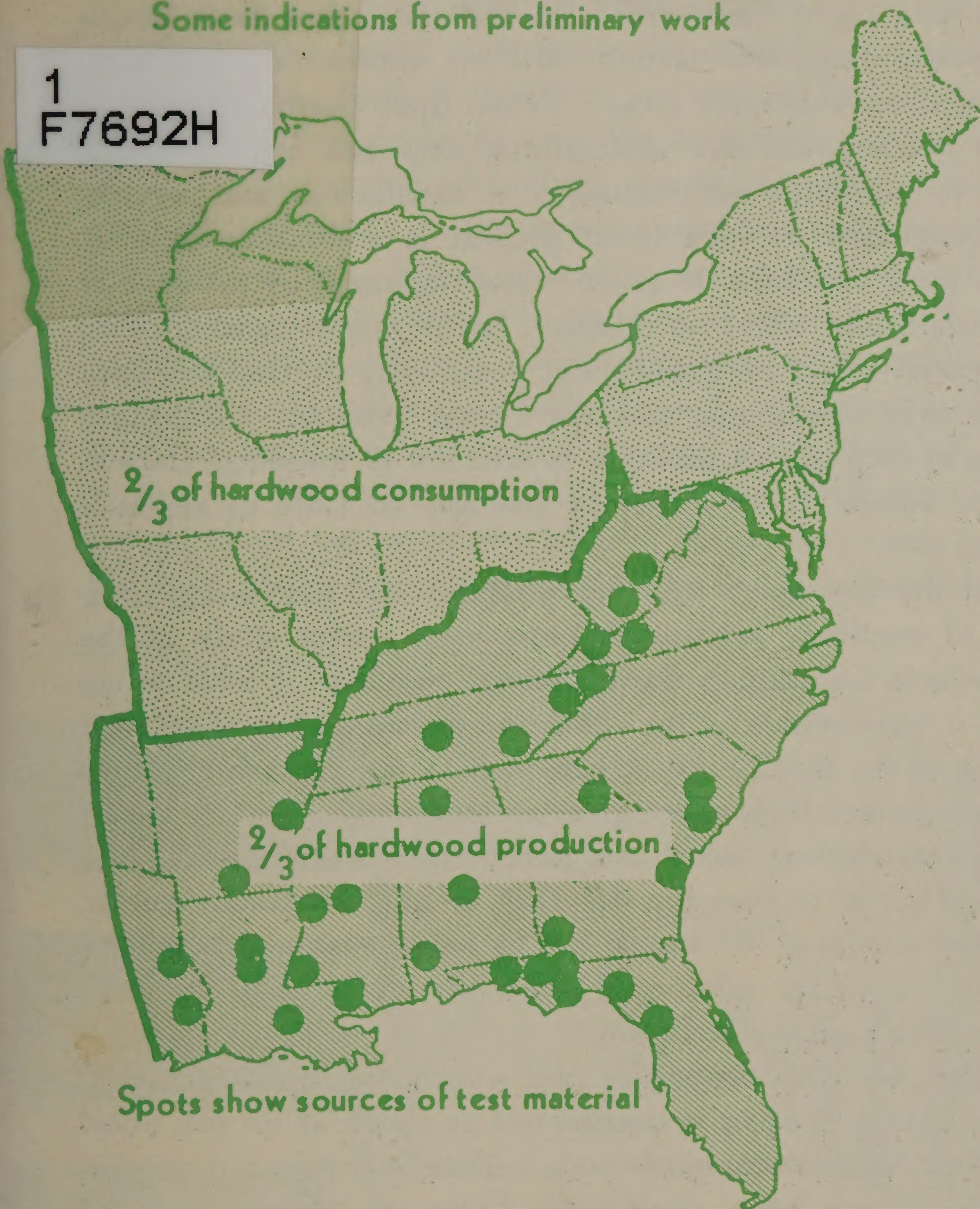
4-1-4 Bietz

HARDWOODS

. . . of the South

Some indications from preliminary work



texture

planing

shaping

turning

bending

warping

cross grain

seasoning

splitting

nail holding

screwholding

gluing

odor & taste

Forest Products Laboratory, Madison, Wis.

Forest Service

U.S. Department of Agriculture

December 1935

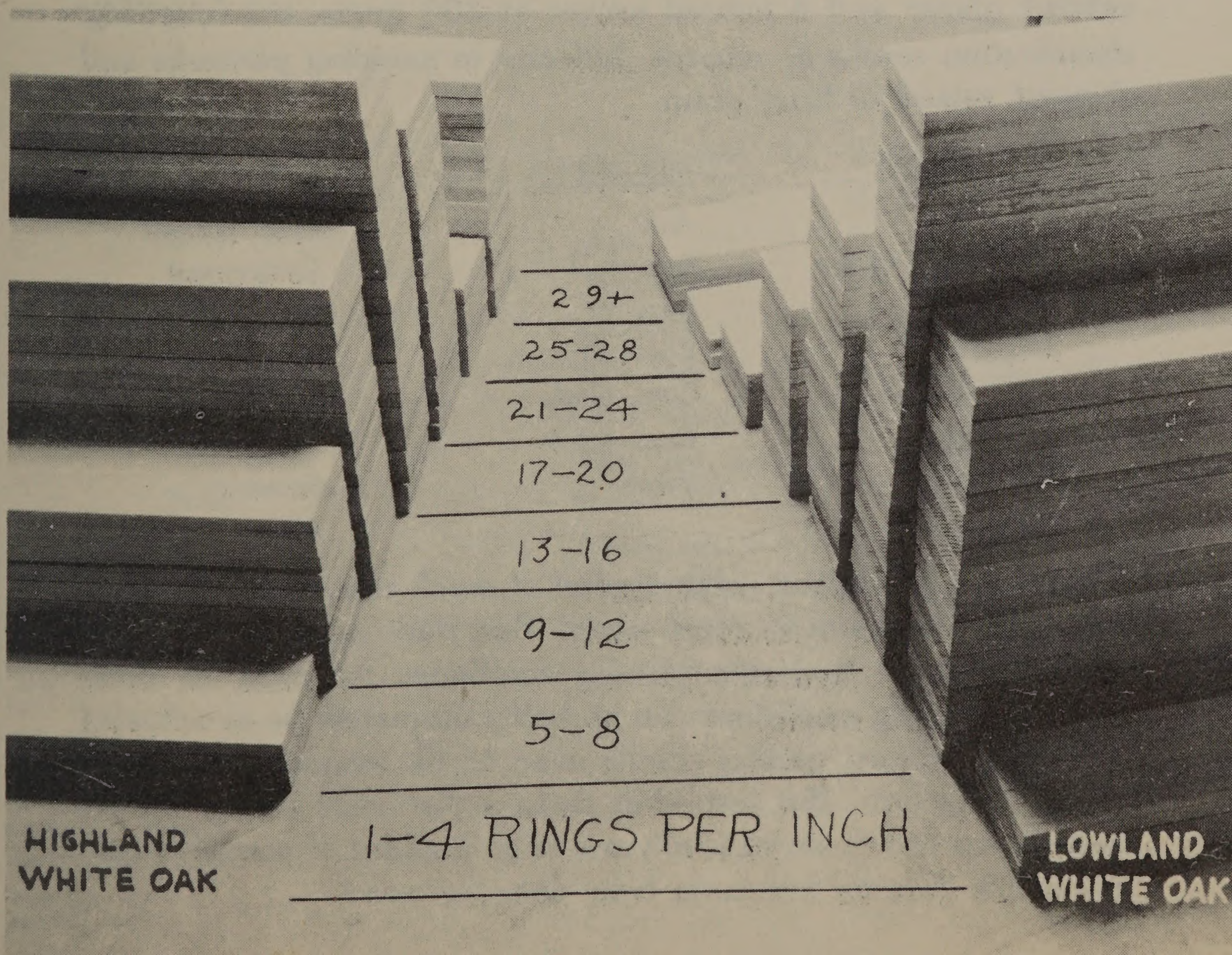
TO MANY CONSUMERS several of the hardwoods from the South are "new" and "different." In the sense that these woods were not among those first used in northern woodworking factories many of them are relatively new. When their characteristics are thoroughly investigated and understood, emphasis on differences gives way to emphasis on likenesses in satisfaction and serviceability. Geography or locality of growth is commonly held by consumers (and the idea is given encouragement by producers) as having important effect on quality. Local growth conditions do have a marked effect on quality, but geography in itself is a poor index of growth conditions, and the Forest Products Laboratory in its years of testing and research is inclined to minimize the importance or reliability of adhering strongly to state or regional distinctions.

Some of the every-day working qualities and machining characteristics of southern hardwoods have been under study at the Forest Products Laboratory during recent months. A wide range of territory is represented in the collection of material used in these tests. Much of the data briefly summarized in the pages that follow deals with properties that, although of an eminently practical nature and basic to satisfactory wood use, nevertheless have never before been systematically explored in the case of any American woods. For this reason most of the results are to be viewed as of a preliminary nature requiring additional work for verification and for following out to logical conclusion.

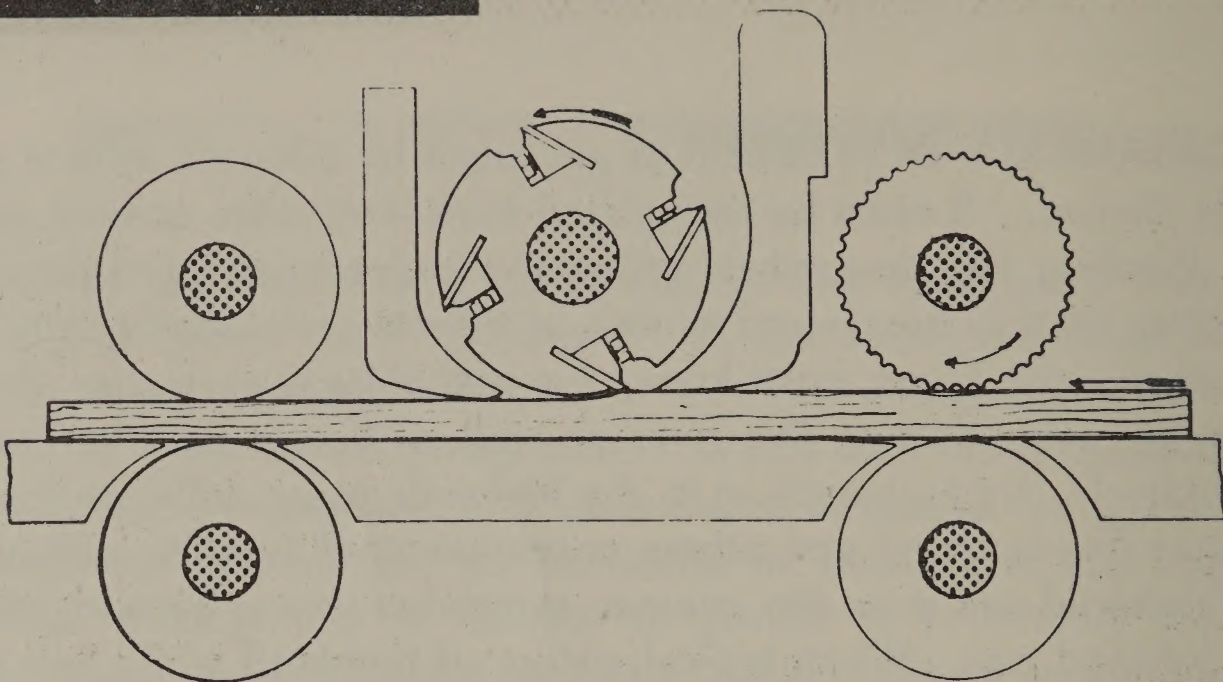
In the case of most properties and woods the results obtained depend on *how* a process is carried out as much as on the wood itself. In work on southern hardwoods to date only inherent species characteristics have been dealt with. Later on attention will be directed to the working out of allowances or of methods of compensating for inherent species characteristics.

TEXTURE

VARIABILITY IN LUMBER as produced by different mills is not to be denied. It must be recognized more and more as time goes on. Pending the time when systems of segregation according to qualities of the clear wood as well as defects are commercially recognized, the buyer must know his mill if he is particular about what he gets. East of this river or west of that is no criterion of quality. In the highlands as in the lowlands some mills are found to have fine-textured and others coarse-textured lumber although the highland oak is on the average somewhat slower growing than the lowland oak. When typical pieces of highland white oak are sorted into piles according to number of rings per inch the result is as shown below, whereas an equal number of typical pieces of lowland white oak fall into the arrangement on the right. It is significant that there is 55 percent of material in the highland oak similar to that in the lowland oak and vice versa. However, the bulk of the highland oak is in the tiers of 17 or more rings per inch and the bulk of the lowland oak is in tiers of 16 or less rings per inch.



PLANING

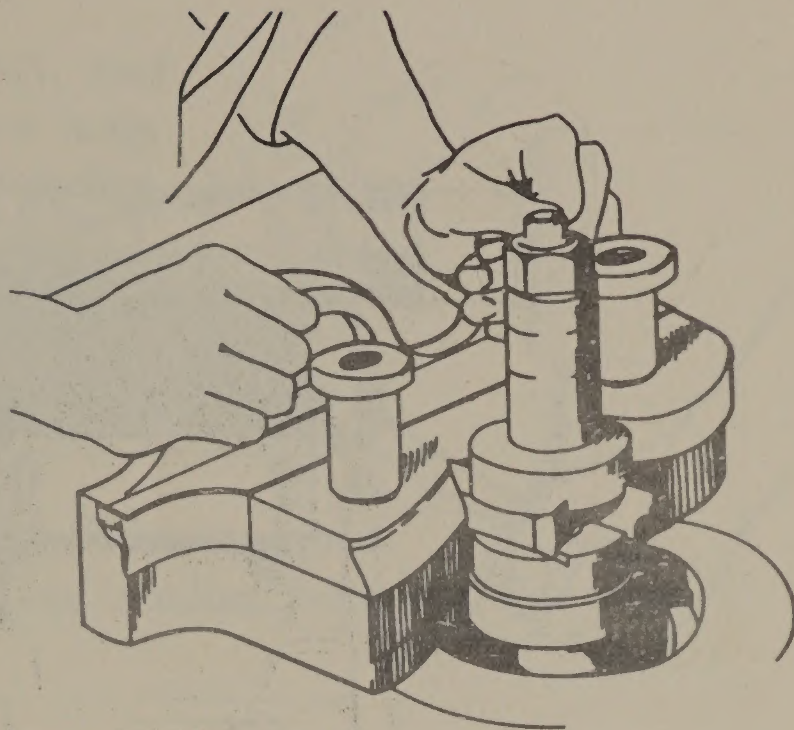


ALMOST ANY WOOD can be planed well if the conditions of speed, moisture content, cutting angle, etc., are right. But some woods must be handled just so, while for others good results are obtainable under a wide range of conditions. Contrary to a popular opinion high cutter head speed (5400 R.P.M. and 54 feet feed per minute) seems to give better results than the common speed of 3600 R.P.M. and 36 feet feed per minute. With a 30-inch cabinet planer and 4 jointed knives at 30° angle, the following classification results as regards difficulty in avoiding pitmarks and chipped, raised, or fuzzy grain.

Least difficult	Intermediate	Most difficult
Beech	Ash	Birch (sweet)
Gum, red and sap	Basswood	Cottonwood
Hackberry	Buckeye	Elm, soft
Magnolia	Chestnut	Hickory
Oak, chestnut	Gum, black	Maple, hard
Oak, red	Gum, tupelo	Maple, soft
Oak, white	Pecan	Sycamore
Poplar, yellow		Willow

The above conditions, while typical of much commercial practice, are not the optimum for every wood. Best trade experience already points to more favorable planing conditions for most of these woods. Planing conditions can probably ultimately be so adjusted as to give almost perfect results even on the woods in the "most difficult" group. But just what these adjustments are, is not yet established and to do so involves a large amount of precision testing which thus far has never been done for wood.

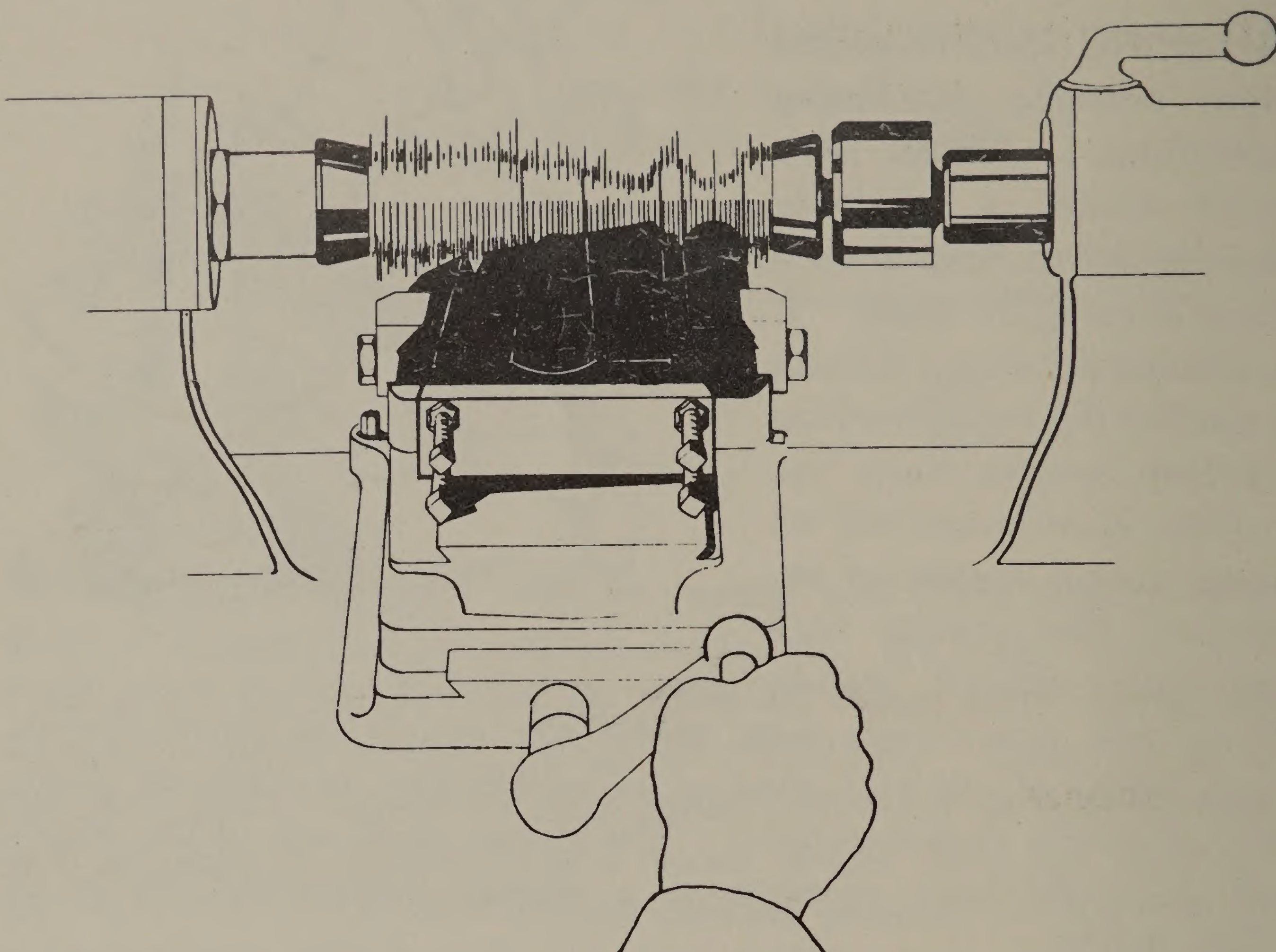
SHAPING



SHAPING IS ONE of the more exacting machining operations. Almost any wood makes a passable showing when shaped at a slight angle to the grain. It is in shaping across the end grain that the big differences between species show up. Further experiment will no doubt reveal means of improving the results with the more difficult woods. Meanwhile preliminary tests group the woods as shown below, smoothness of cut and absence of splintering or chipping being the governing considerations. The shaper used was of the standard two-knife type running at a typical commercial speed of 7200 R.P.M.

Least difficult	Intermediate	Most difficult
Birch (sweet)	Ash	Basswood
Hickory	Beech	Buckeye
Maple, hard	Chestnut	Cottonwood
Oak, chestnut	Elm, soft	Magnolia
Oak, red	Gum, black	Tupelo
Oak, white	Gum, red and sap	Willow
Pecan	Hackberry	
Sycamore	Maple, soft	
	Poplar, yellow	

TURNING



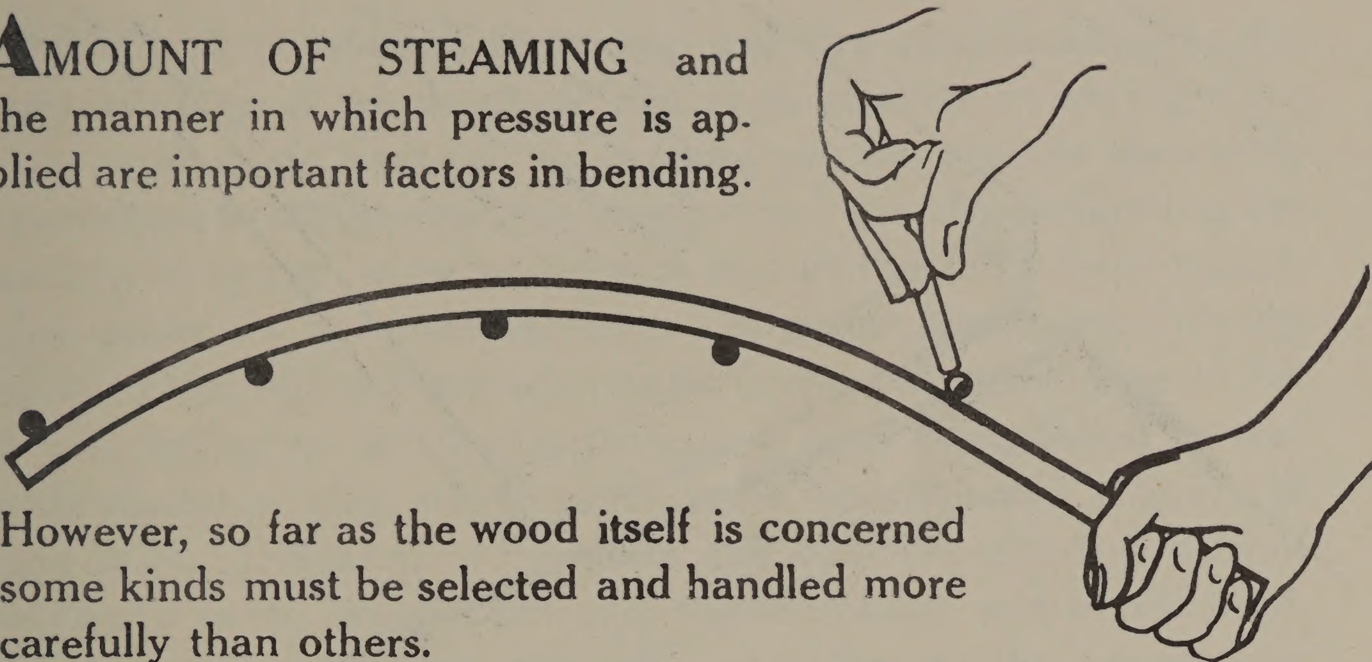
RELATIVE YIELD OF "SMOOTH" TURNINGS

Beech	93	Oak, red	84	Maple, soft	78
Pecan	89	Oak, white	82	Gum, black	75
Gum, red & sap	86	Ash	81	Elm, soft	70
Hickory	86	Hackberry	79	Basswood	70
Sycamore	85	Magnolia	79	Cottonwood	70
Yellow poplar	84	Tupelo	79	Willow	60

(Modified back knife lathe: 6, 12, 20% moisture content.)

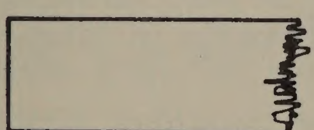
SOME OF THE WOODS, like beech and pecan, turn relatively well regardless of moisture content. Other woods, like cottonwood and willow, give good turnings only if dried down to about 6% moisture content. In general, the heavier woods turn better than the light ones, and heavy pieces turn better than light pieces in the same wood. The main points considered in quality of turnings were general smoothness, sharpness of detail, and occurrence of broken or chipped edges, as affecting the amount of sanding that must be done to make them acceptably smooth for use.

AMOUNT OF STEAMING and the manner in which pressure is applied are important factors in bending.

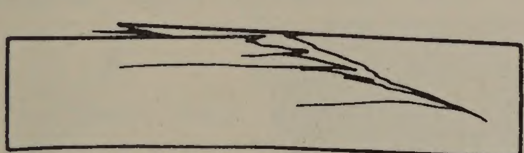


However, so far as the wood itself is concerned some kinds must be selected and handled more carefully than others.

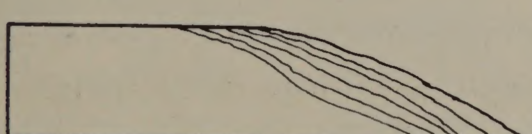
In bending ¾-inch squares on a 20-inch radius without end pressure or any support on the outside of the bend and without selection beyond excluding knotty, unsound, or checked pieces, the following classification applies:



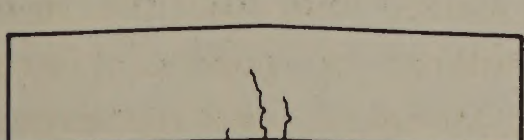
Brash break - the most common type in oak.



Tension failure - much the most common type in ash, elm, magnolia, soft maple, and cottonwood.



Cross grain failure - not uncommon in black gum, red gum, tupelo, and sycamore.

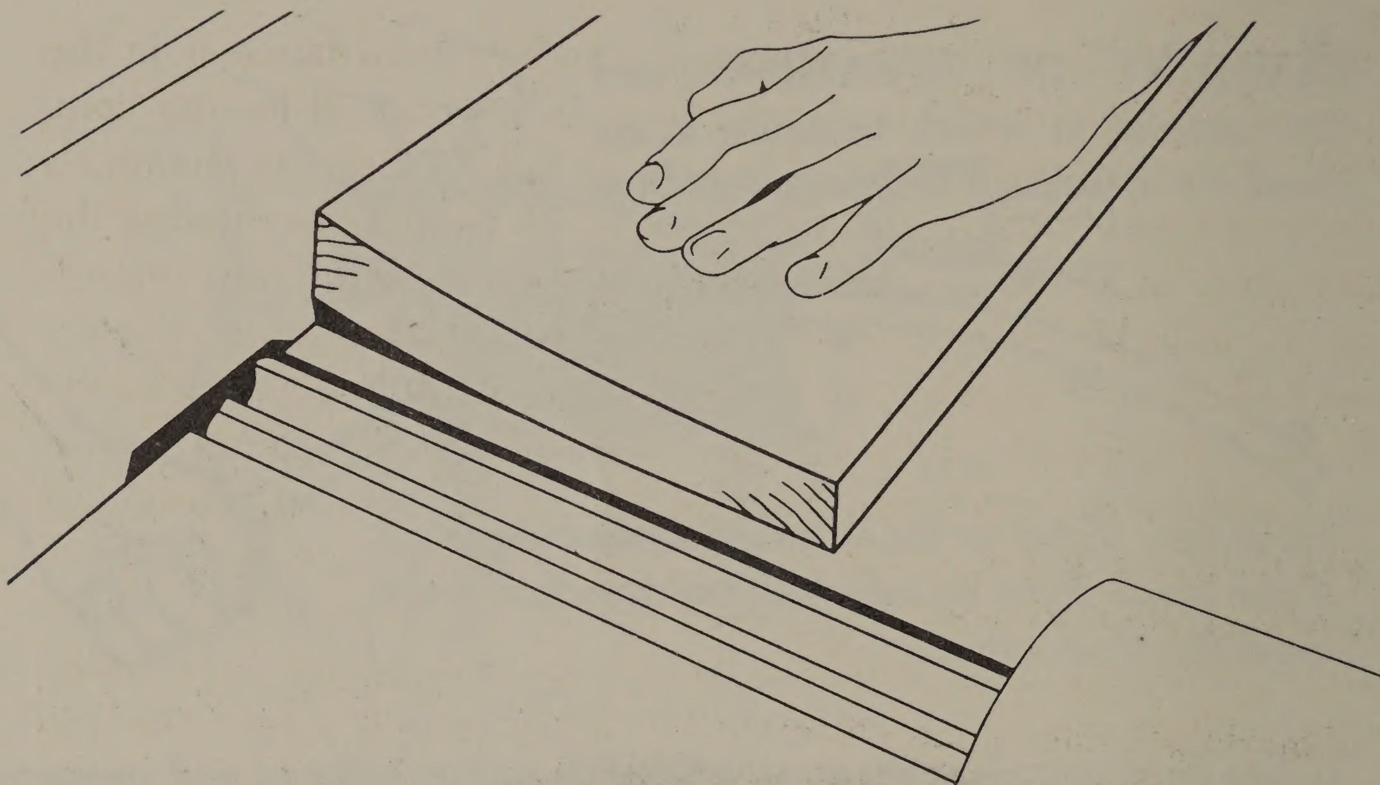


Compression failure - sometimes found in softer woods like yellow poplar.

BENDING BREAKAGE

Oak, white	9	percent
" , red	14	"
" , chestnut	18	"
Magnolia	18	"
Birch, sweet	22	"
Elm, soft	28	"
Ash	36	"
Beech	40	"
Gum, red and sap	44	"
Maple, soft	47	"
Chestnut	50	"
Poplar, yellow	51	"
Maple, hard	51	"
Tupelo	53	"
Gum, black	66	"
Cottonwood	69	"
Sycamore	84	"
Basswood	95	"

WARPING & CROSS GRAIN



WARPING IS CONTROLLABLE. Some species necessitate greater care to prevent warp than others; hence it is necessary to know the inherent warping characteristics of different woods. The importance of warp shows up in the amount of waste in fabrication. Twist is the most serious type of warp.

Slight warping tendencies: Ash, Basswood, Birch (sweet), Buckeye, Chestnut, Hackberry, Maple (hard), Maple (soft), Oak (chestnut), Oak (white), Oak (red), Poplar and Willow.

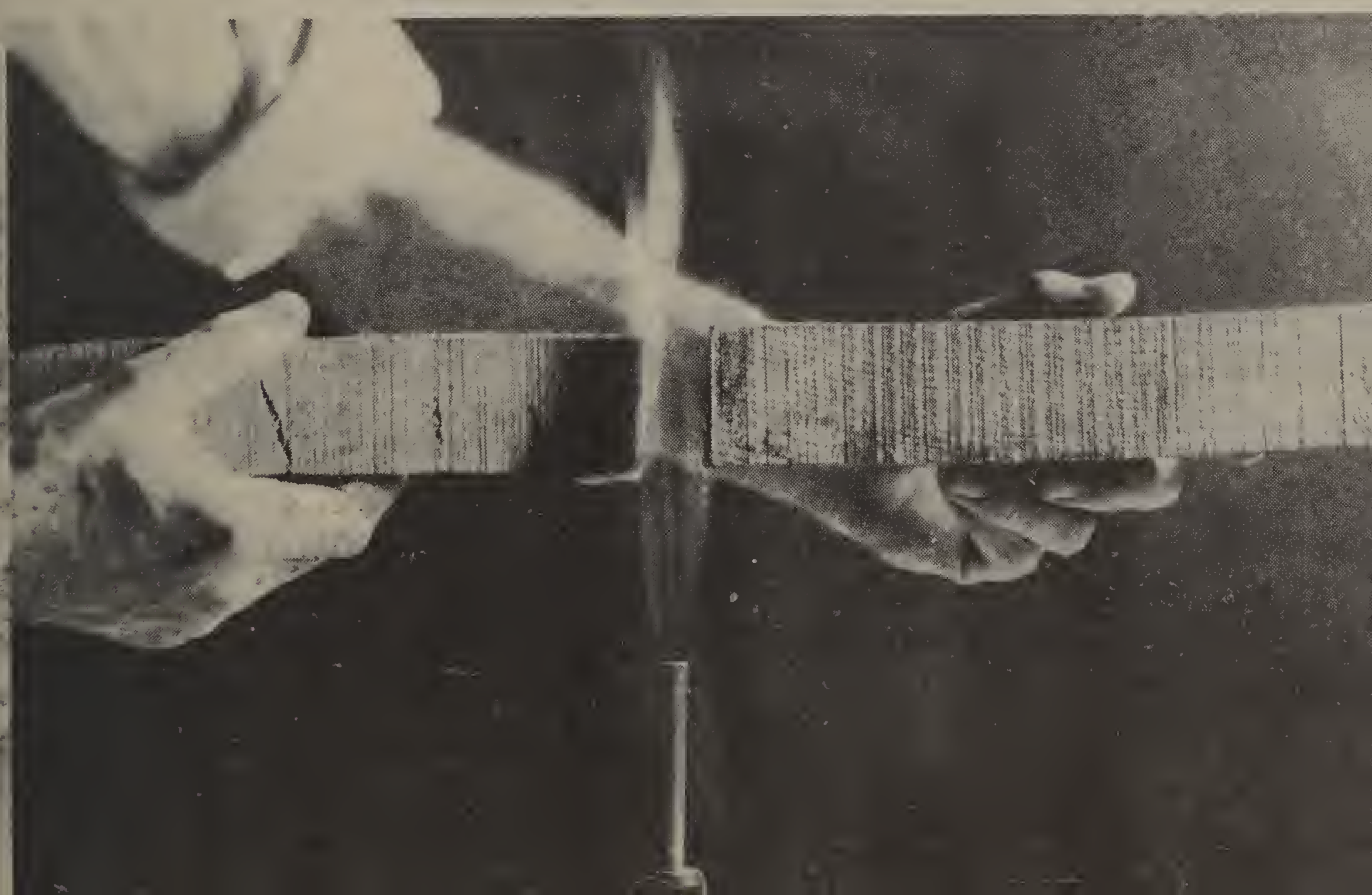
Moderate warping tendencies: Beech, Cottonwood, Elm (soft), Hickory, Magnolia and Pecan.

Greatest warping tendencies: Gum (black), Gum (red & sap), Sycamore and Tupelo.

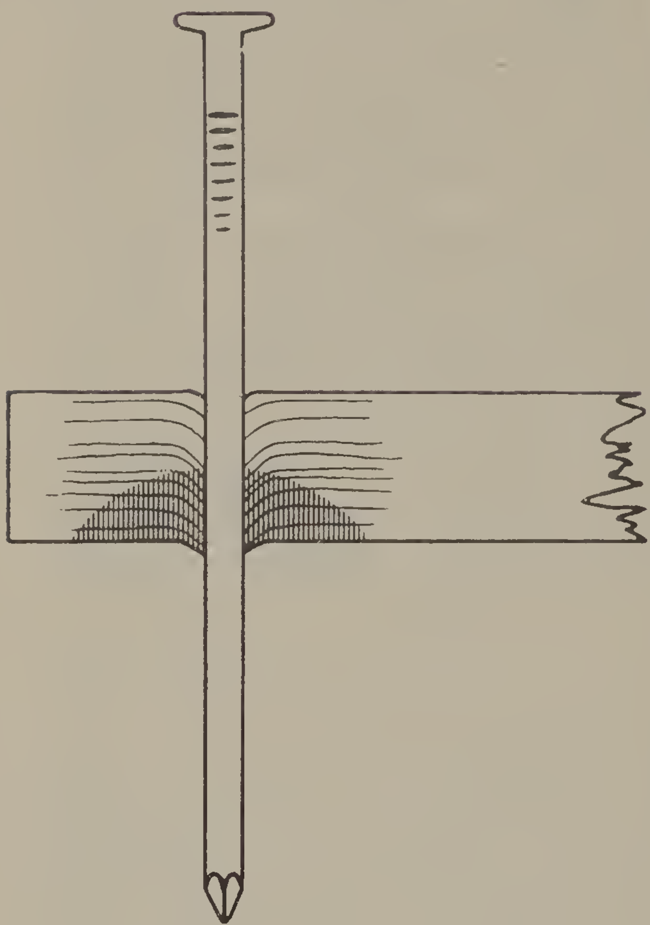
The four woods of greatest warping tendencies, black gum, red gum, sycamore and tupelo, are those in which interlocked grain (the most extreme form of cross grain) is most common. Elm and cottonwood warp somewhat less and have less interlocked grain. In the remaining woods interlocked grain is rare or lacking but spiral grain occurs to some extent in all of them. In general, woods that warp little have spiral grain with an average slope of not over 6% as compared with 7-9% slope in woods of greater warping tendencies. Cross grain tends to increase warp, breakage and defective machinework, but careful selection of material will go far to avoid dissatisfaction from this source.

CHEMICAL SEASONING & FIREPROOFING

A PROCESS combining seasoning and fire retardance is in the laboratory stage of development and gives promise of having commercial application later on. In carrying out the process chemicals are permitted to diffuse into the green wood, thereby facilitating the seasoning of heavy refractory woods and at the same time imparting fire retardant and possibly other important properties. Heavy plank of refractory oak species which honeycomb in defiance of the best kiln drying or air drying technique have been found to season satisfactorily after being soaked in a concentrated solution of certain salts. Diffusion of common salt solution into the natural moisture in green wood decreases the shrinkage and hence minimizes honeycombing and checking even though the penetration of the salt is not deep. But with the use of certain other salts and longer soaking to accomplish deeper penetration the wood is not only less susceptible to honeycombing but is made sufficiently fire resistant that it will not support combustion. Witness the two pieces cut from matched oak planks: the one on the left kiln dried with the greatest of care but honeycombed nevertheless and readily inflammable, and the one on the right, soaked in a salt solution before drying, without honeycombing, and incapable of supporting combustion.



SPLITTING IN NAILING

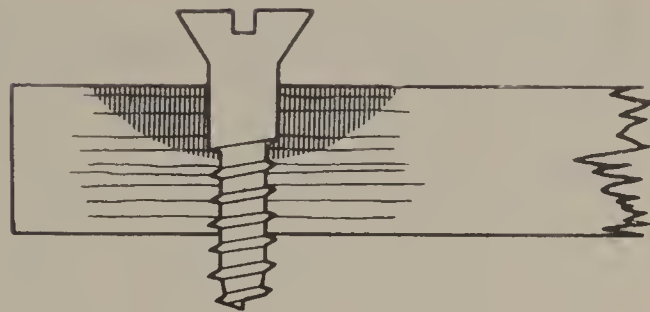


FOR BOXES AND CRATES suitability depends among other factors on the holding power of the nails which in turn depends largely upon splitting tendencies of the species. Splitting is controllable within limits by size and spacing of nails and the way they are driven but even so the kind of wood is itself a factor. Driving a nail tends to distort the fibers next to the nail downward, causing a downward accumulation of stress with splitting making its first appearance on the under side.

Splitting tendencies of the different woods as judged by percent of complete splits in driving 7d box nails in thin air dry boards (3/8), close to the end (1/2 inch and 3/8 inch) are as follows:

Splits by less than 25% of nails	Splits by 25 to 40% of nails	Splits by over 40% of nails
Buckeye	Ash	Beech
Cottonwood	Basswood	Birch, sweet
Elm, soft	Chestnut	Hackberry
Poplar, yellow	Gum, black	Hickory
Sycamore	Gum, red & sap	Maple, hard
Willow	Magnolia	Maple, soft
	Oak, red	Oak, chestnut
	Oak, white	Pecan
	Tupelo	

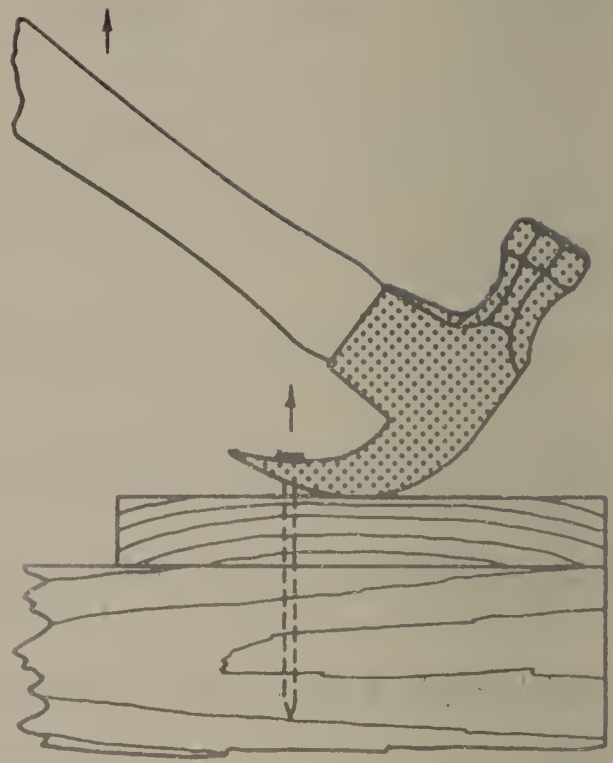
SPLITTING IN SCREWING



WITH WOOD SCREWS in drilled holes the tendency is for any splits that develop to start on the upper side of the board. The unthreaded portion just below the head exerts a wedging effect. Pronounced distortion of fibers alongside the screw is lacking. Some woods that split most readily with nails make a much better showing with screws. The classification of species that follows is based on the percent of screws of various sizes causing complete splits under drastic conditions, viz. in thin (3/8") air dry stock, screws driven 1/2" and 3/4" from the end.

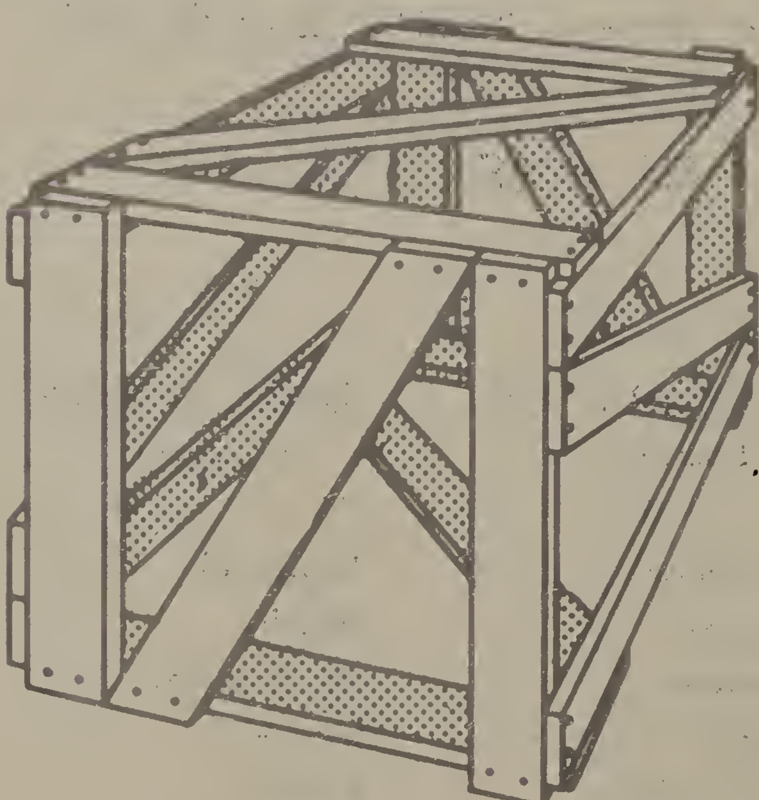
Splits by 20 to 29% of screws	Splits by 30 to 39% of screws	Splits by over 40% of screws
Ash	Gum, black	Basswood
Cottonwood	Gum, red	Beech
Elm, soft	Hackberry	Birch, sweet
Magnolia	Hickory	Buckeye
Oak, red	Maple, soft	Chestnut
Oak, white	Oak, Chestnut	Maple, hard
Sycamore	Pecan	Tupelo
	Poplar, yellow	
	Willow	

NAIL HOLDING



FOR SOME USES the suitability of the different species of wood is largely dependent on their nail- and screw-holding ability. With this in mind, studies have been made to determine the nail- and screw-holding properties of southern hardwoods, both in resistance to direct pull and sidewise thrust.

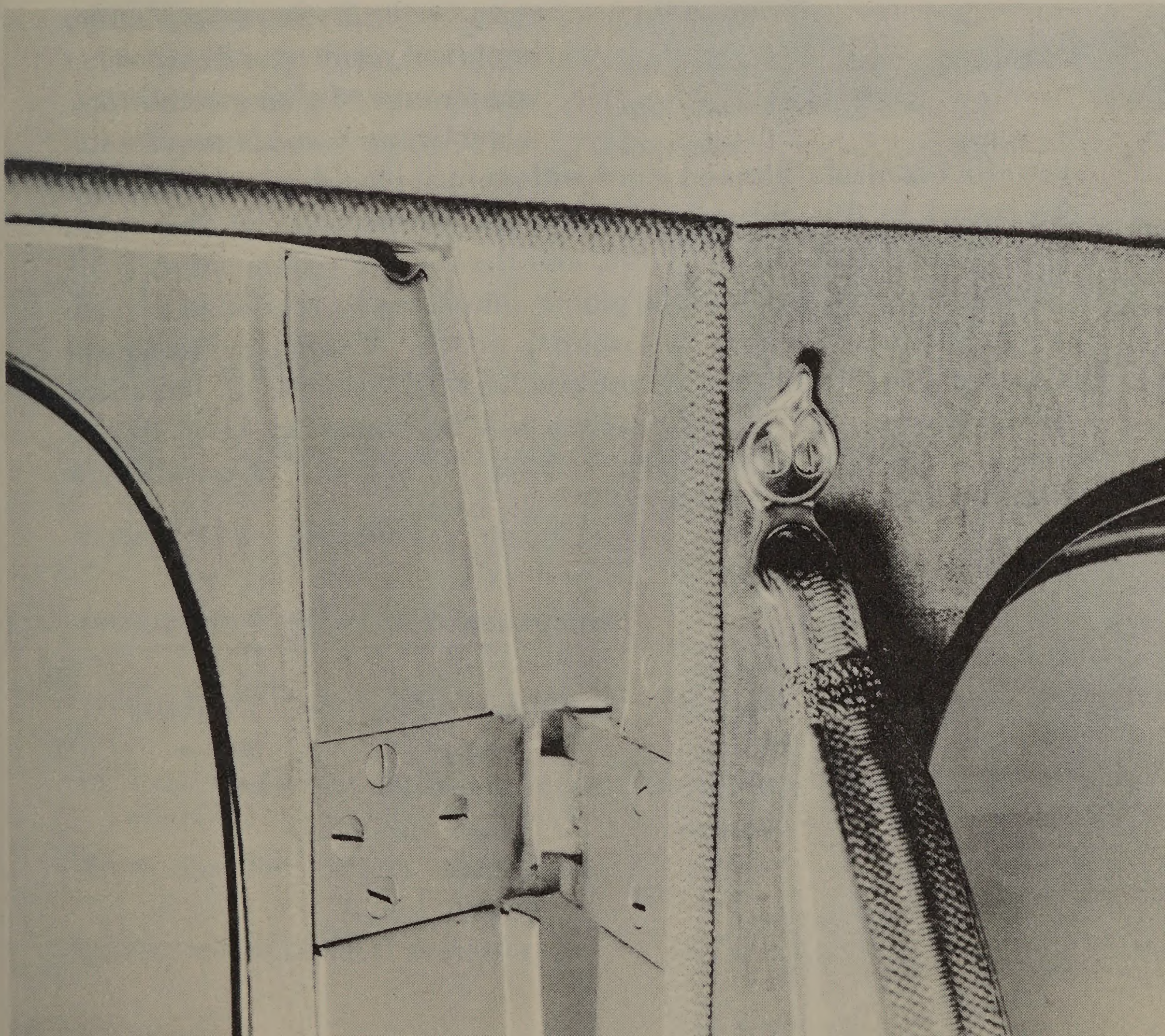
As a result of the tests made the woods have been divided into the three groups, group 3 representing the woods of highest rank, and group 1 the lowest. The actual loads for screws and nails in the species of group 1 are from $\frac{1}{3}$ to $\frac{1}{2}$ those of group 3, with group 2 intermediate. The rating of the species is closely related to their density or dry weight.



Average values based on tests of a number of specimens are used in this grouping of species. By carefully eliminating the poorer light weight pieces, a large part of some species such as ash can be put into the next higher group. It follows also that the utility of species in the lower groups may be enhanced

by using a greater number or larger size of nails or screws than is required for group 3 woods.

Group 1	Group 2		Group 3
Basswood	Ash	Magnolia	Beech
Cottonwood	Elm, soft	Maple, soft	Hickory
Poplar, yellow	Gum, black	Tupelo	Oak, red
Willow	Gum, red	Sycamore	Oak, white
	Hackberry		Pecan



GLUING

SATISFACTORY JOINTS can be produced in all the southern hardwoods tested with either animal, casein, or vegetable (starch) glue, but some species, usually the denser ones, require more care than others in regulating the gluing conditions to avoid weak joints.

Group 1 woods, for example, demand the most careful control of gluing conditions to obtain joints that, when tested, will break entirely in the wood.

In Group 2 woods satisfactory joints will result over a somewhat wider range of gluing conditions, while Group 3 woods require still less strict control. Starved joints with animal glue, for instance, need be feared in this group only when the temperature of the room and wood is high, the glue thin, and the assembly time short.

It is recommended that the gluing conditions be regulated according to the requirements of Group 1 woods. These conditions will produce good results on all the southern hardwoods. A complete discussion of good gluing practice will be found in U. S. D. A. Bulletin 1500, entitled "The Gluing of Wood." (Government Printing Office, Washington, D. C., 25 cents).

Group 1		Group 2	Group 3
Beech	Magnolia	Ash	Hackberry
Elm	Oak, red	Basswood	Willow
Gum, black	Oak, white	Cottonwood	
Gum, red	Sycamore	Maple, soft	
Hickory	Tupelo	Pecan	
		Poplar, yellow	

ODOR & TASTE

BUTTER, more susceptible to taints than any other food product, when used as the test medium by a dairy expert discloses that several southern hardwoods, in addition to the favorites, ash and yellow poplar, are suitable for food containers from the taste and odor standpoint. Taking ash, the best, as 100, the woods rank as follows:

Ash	100	Elm, soft	68
Maple, soft	84	Gum, black	64
Hackberry	83	Cottonwood	58
Sycamore	80	Gum, red	58
Beech	73	Magnolia	55
Yellow poplar	71		

Other properties than odor and taste must, of course, be taken into account when selecting a wood for food containers, but any pronounced tendency to impart odor or taste is in itself sufficient to bar a wood from use for certain of the more taint-susceptible food products.

In Conclusion

STUDIES SUMMARIZED in the foregoing pages do not by any means cover the entire field. Phases of machining and woodworking problems that have been touched upon thus far, necessarily somewhat lightly, should be gone into much more deeply to discover the best working conditions for all woods and all operations. In addition there are several other operations, such as boring, mortising, sanding, carving, and finishing. Behind it all lies the urgent need for all possible information that will contribute to greater satisfaction in the use of wood and that will help wood hold its own in the new competition that confronts forest industries.

The work dealt with in this booklet is a part of a program of research under way at the Forest Products Laboratory to aid the public in the use of wood and in the stabilization of the nation's forest-land and forest-industry enterprise. Specific work summarized here on machining and related properties is that of E. M. Davis; on seasoning, that of W. K. Loughborough; on nail and screw holding, that of J. A. Scholten; and on gluing, that of Don Brouse.